THE WEATHER AND CIRCULATION OF AUGUST 1961

Record Heat from the Northern Plains to the Pacific Coast

JAMES F. ANDREWS

Extended Forecast Branch, U.S. Weather Bureau, Washington, D.C.

1. HIGHLIGHTS

August 1961 continued the succession of hot dry months in the northwestern United States [1] with average and daily temperatures reaching record levels in many areas. Severe drought persisted in the Northern Plains and by the end of the month conditions were comparable with the most severe drought of other years.

The Midwest and South were unseasonably cool, continuing a pattern that began in April of this year. The most persistent coolness occurred in the western Gulf States where mean temperatures for the month were at or near record levels.

This sharp contrast in weather regimes was also characteristic of the summer season and was related to an abnormal mid-tropospheric circulation.

2. MONTHLY MEAN CIRCULATION

The average circulation pattern at 700 mb. for August 1961 (fig. 1) featured an unusually strong ridge over western North America. The height anomaly center associated with this ridge was the highest ever observed in this area during the Extended Forecast Branch period of record (since 1933). A companion feature of this ridge was a deeper than normal trough over the southeastern United States.

In the Pacific and North America the pattern of 700-mb. height and its anomaly exhibited a meridional character, with a deep mid-Pacific trough helping to support the strong ridge in the climatologically favored area over western North America (fig. 1). Elsewhere in the hemisphere, from the Atlantic across Asia, the circulation was markedly zonal.

The middle-latitude westerlies were stronger than normal and displaced northward during August over the western portion of the hemisphere (figs. 2, 3). Greatest displacement was over North America where a band of wind speeds as much as 5 m.p.s. above normal was observed across central Canada (fig. 3B). These fast westerlies were related to the deep cyclonic center in northeastern Canada and strong ridge to the west (fig. 1). In the United States, however, weaker than normal westerlies predominated. The contrasting wind speed anomaly pattern in North America (fig. 3B) is also inherent in the 700-mb. height anomaly pattern (fig. 1). Across Canada the anomalous flow was westerly, while in the United States easterly anomalous flow prevailed.

The westerlies over the eastern portion of the hemisphere were displaced south of their normal August position, primarily as a result of the blocking High and area of 700-mb. height anomaly centered near Novaya Zemlya (figs. 1, 3). Fast westerly flow prevailed across the Atlantic, Europe, and into Asia, with greatest wind speed departures, as much as 6 m.p.s., in central Europe (fig. 3B).

3. AVERAGE MONTHLY WEATHER

RECORD HEAT AND DRYNESS IN THE NORTHWEST

The northwestern United States, from the northern Great Plains to the Pacific coast, experienced one of the hottest and driest months ever recorded. Temperatures for August averaged from 4° to more than 6° F. above normal in all but coastal areas (fig. 4), while less than half the normal amount of precipitation fell in the Northern Plains (fig. 5). In many areas stations with long-period records reported that August 1961 was the warmest month of record. A representative list of these stations is shown in table 1.

The hottest weather occurred quite generally during the first week when a strong ridge dominated western North America. Extreme heat from the Cascade Mountains to the northern Great Plains sent temperatures well over 100° F., with many stations establishing new absolute

TABLE 1.—*Monthly mean high temperature records established in August 1961*

Station	Temperature (°F.)		
	Average monthly	Departure from normal	Year records began
Devils Lake, N. Dak.	72.6	5.8	1904
Williston, N. Dak.	74.9	6.8	1878
Rapid City, S. Dak.	77.2	6.3	1887
Billings, Mont.	76.2	5.2	1894
Glasgow, Mont.	75.0	6.1	1893
Great Falls, Mont.	72.4	5.3	Before 1900
Havre, Mont.	72.9	4.9	1879
Sheridan, Wyo.	73.1	4.5	1907
Seattle, Wash.	69.3	4.1	1892
Portland, Oreg.	72.2	3.8	1902

[1] Reference to the United States in this paper will not include Alaska or Hawaii.

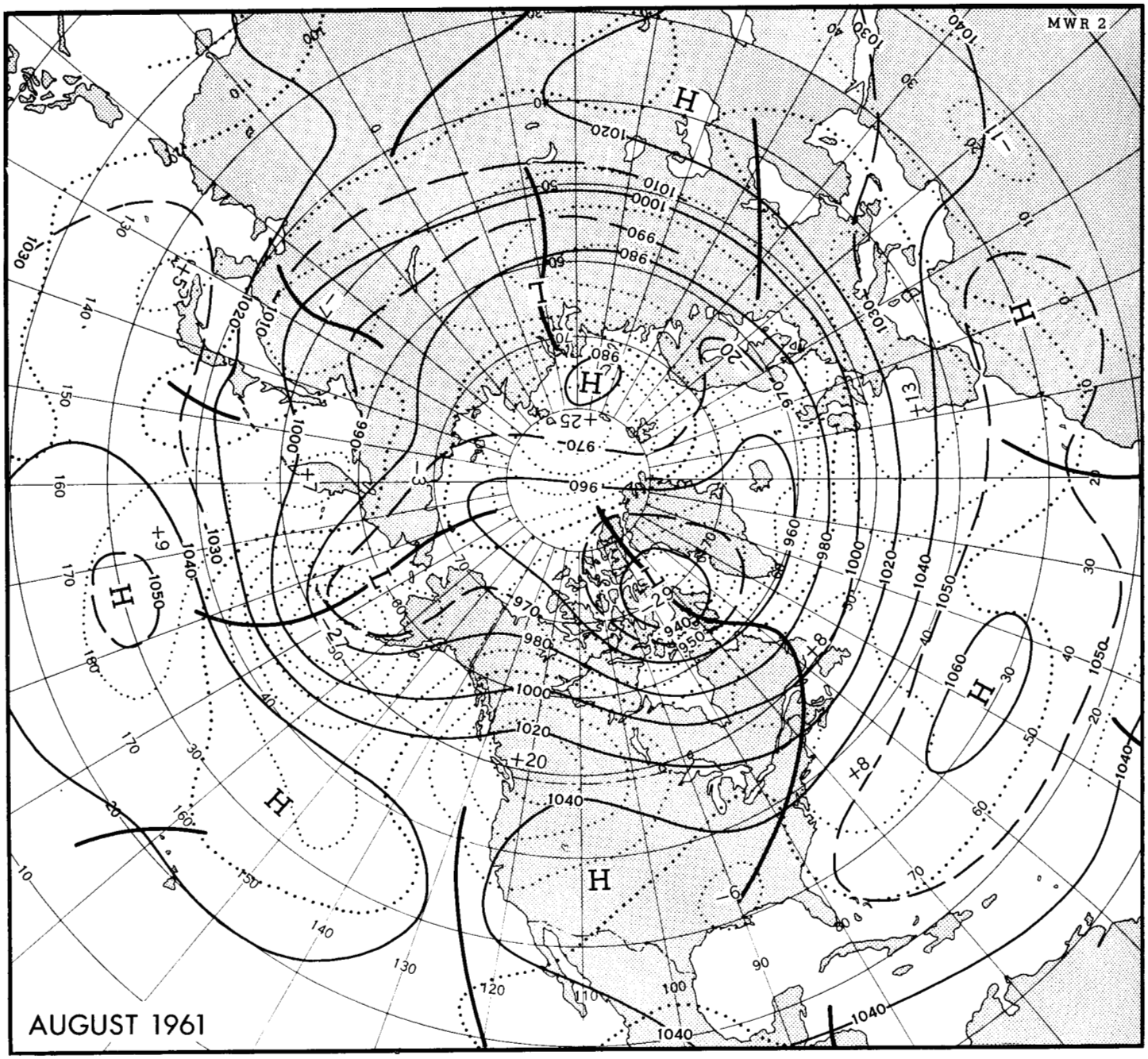

FIGURE 1.—Mean 700-mb. contours (solid) in tens of feet, and departures from normal (dotted) in 50-ft. intervals, for August 1961. Important circulation features were the unusually strong ridge over western North America and deep trough over southeastern United States.

TABLE 2.—*Maximum temperatures during August 1961 which equaled or exceeded previous highest recorded for any month.*

Station	Temperature (°F.)	Date
Helena, Mont.	*103	5
Kalispell, Mont.	105	5
Missoula, Mont.	105	4
Havre, Mont.	111	5
Boise, Idaho	110	4
Spokane, Wash.	*108	4
Pendleton, Oreg.	113	4

*Equaled previous record.

maximum temperature records as shown in table 2. In addition to the stations listed, a record high August temperature of 115° F. was reported at Lewiston, Idaho on the 4th. Nights were also unusually hot in the northern Plains where minima were occasionally in the mid-70's.

August continued the series of dry months that has left soil moisture reserves at a critically low level. At Williston, N. Dak., only 10 percent of the normal moisture fell, the driest August since observations began in 1878. Much of the precipitation in the Northwest was in the

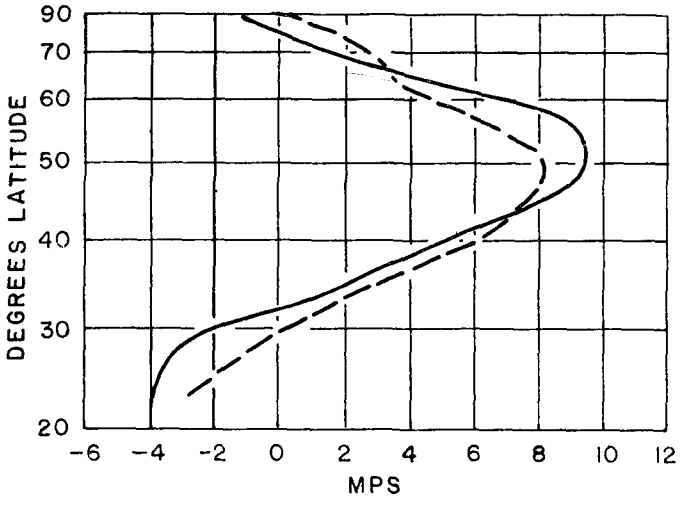

FIGURE 2.—Mean 700-mb. zonal wind speed profiles in the western portion of the Northern Hemisphere for August 1961 (solid) and August normal (dashed). The middle-latitude westerlies were stronger than normal and displaced northward.

form of widely scattered light showers which failed to add to soil moisture reserves.

Drought conditions in the Northwest were related to the abnormally strong ridge and area of positive 700-mb. height anomaly over western North America (fig. 1). Advection of vorticity from the deep mid-Pacific trough strengthened this ridge, normally found over western North America during the summer months. The westerlies, displaced some 10° north of their normal position over western Canada (fig. 3A), diverted cool, moist Pacific air masses well to the north of the drought area. At the end of the month, however, progression of the long-wave pattern began, thus bringing an abrupt end to the heat wave in the Northwest along with the first substantial rains of the month to Washington and northern Oregon.

PERSISTENT COOLNESS IN THE MIDWEST AND SOUTH

This was the fifth consecutive month that temperatures have averaged below normal in the area from the central Plains to the Appalachians and southward to the lower Mississippi Valley (fig. 1 in [1] and fig. 4). Greatest departures during August, as much as −4° F., were observed in eastern portions of the central and southern Plains. This was the coolest August of record at Shreveport, La., and Austin and Midland, Tex. Daily temperatures averaged below normal on nearly every day of the month in the west Gulf States with some cities, such as Jackson, Miss. and Shreveport, La., never exceeding normal.

These cool conditions were related to the trough over the Southeast and its associated large area of negative 700-mb. height anomaly (fig. 1). Furthermore, this circulation favored the unusually far southward displacement of cold fronts with their attendant cool air masses.

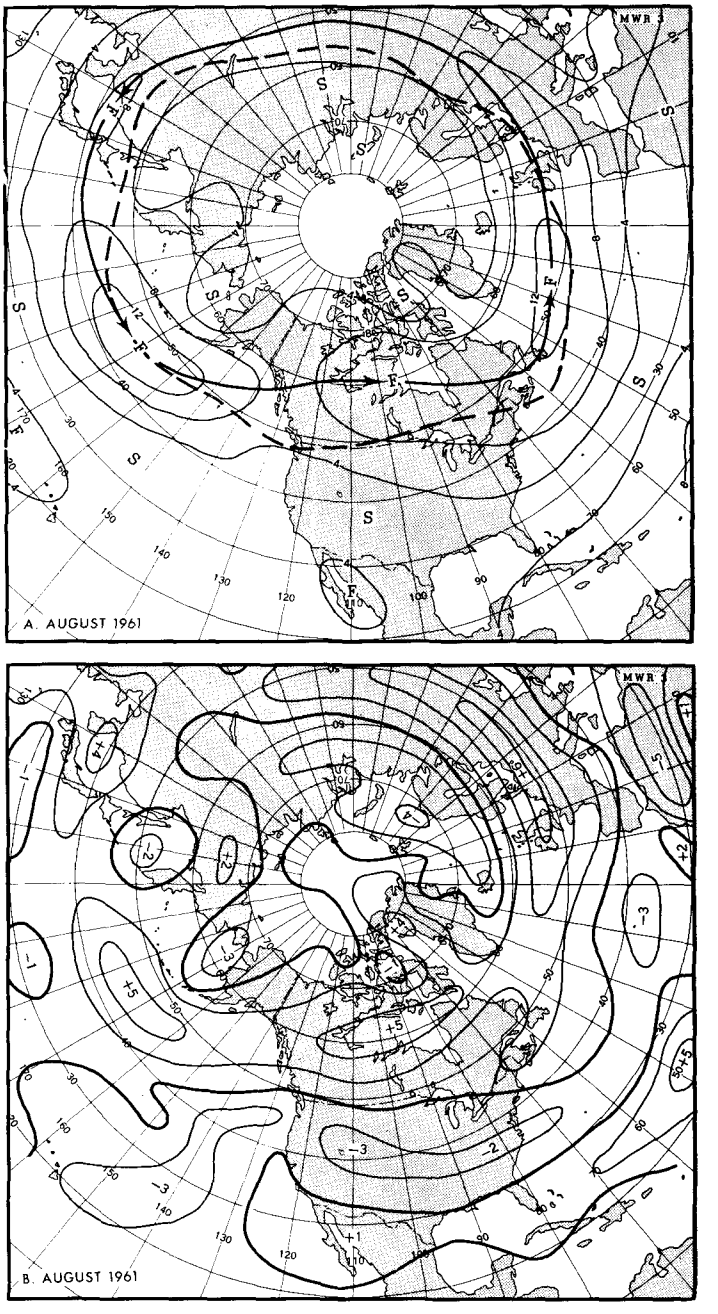

FIGURE 3.—(A) Mean 700-mb. isotachs, and (B) departures from monthly normal wind speeds, both in meters per second, for August 1961. Solid arrows in (A) indicate principal axes of maximum wind speeds, and dashed arrows their normal August positions. The westerlies over North America were displaced north of normal.

The distribution of precipitation bore a nearly typical relationship to the 700-mb. circulation. Less than normal amounts fell generally west of the mean trough while greater than normal amounts fell east of the trough in stronger than normal southerly flow (figs. 1, 5). Following two months of excessive precipitation, central Texas was unusually dry with the Dallas-San Antonio areas receiving less than 10 percent of their normal amounts. Frequent

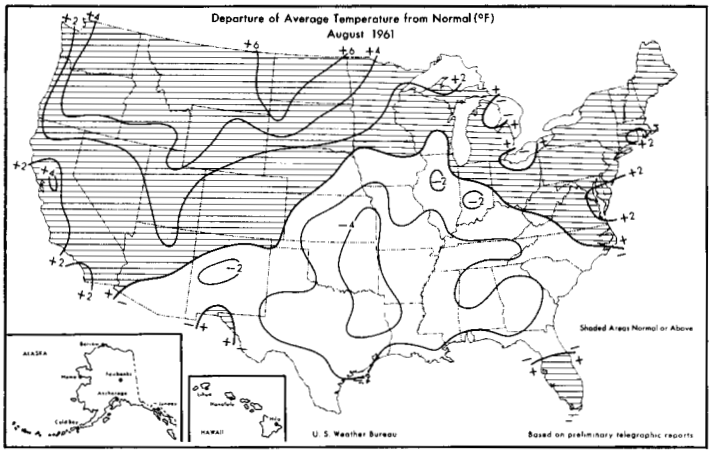

FIGURE 4.—Departure of average surface temperature from normal (°F.) for August 1961. A strong temperature anomaly gradient prevailed in the Midwest. (From [8].)

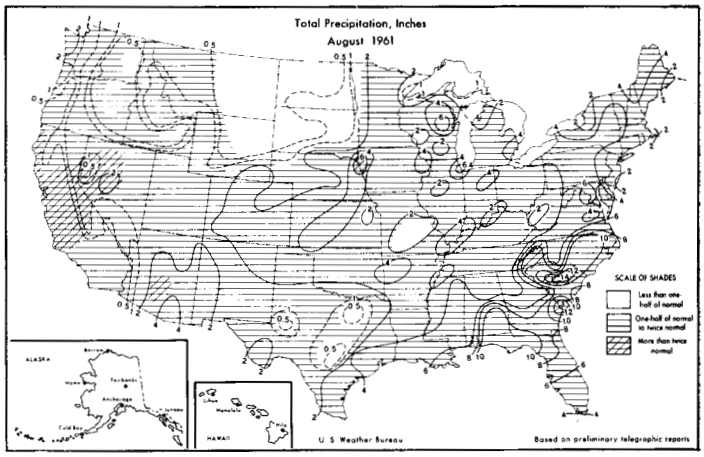

FIGURE 5.—Total precipitation (inches) for August 1961. The Northern Plains were very dry. (From [8].)

showers in the South Atlantic States resulted in many rainy days (0.01 inch or more) with Charleston, S.C., having 19 such days, the greatest number in August since 1898.

WEATHER ELSEWHERE IN THE NATION

A warm wet weather regime prevailed in the Southwest during August. Temperature departures were rather small, +2° F. or less in most areas (fig. 4), while precipitation amounts were mostly greater than normal.

The Southwest moist tongue was unusually active with shower and thunderstorm activity very frequent. Ely, Nev., had 24 days with thunderstorms, the greatest number of days with thunderstorms ever recorded there in any month in any year. Some of this activity spread into California where precipitation in August is very uncommon. The warm showery weather in the Southwest was associated with above normal mid-tropospheric heights and easterly anomalous flow (fig. 1).

The Northeast was also warmer than normal with temperature departures mostly less than 2° F. (fig. 4), while precipitation was generally near normal. In New England, the first 20 days of the month were very dry, the result of westerly anomalous flow in mean trough conditions over the area. During the latter part of the month this trough retrograded and weakened. As a result south and southeasterly anomalous flow became established, accompanied by frequent periods of precipitation. Most of the month's total rainfall fell at this time.

4. TROPICAL STORM ACTIVITY

During any August one or more tropical storms can be expected to develop in the Caribbean or North Atlantic [2], but none occurred in August 1961. It is generally considered that tropical storm development is related to the strength and position of the middle-latitude westerlies [3]. During this August the average circulation appeared quite favorable for generation of such storms. The 700-mb. height anomaly pattern agreed quite closely with the findings of Ballenzweig [4] for maximum storm occurrence. Furthermore, the associated upper-level westerlies were displaced north of normal (fig. 3A). It is evident that some of the basic elements necessary for tropical storm development were missing.

Tropical storm activity was confined primarily to the western Pacific, where four storms developed, three of which reached typhoon intensity.

Typhoon June developed near 12° N., 133° E. on the 1st. This storm moved steadily northwestward, losing much of its strength as it passed over Taiwan on the 6th, finally dissipating after moving into China on the 8th. Typhoon Kathy first appeared near Iwo Jima on the 15th. It also moved northwestward, striking Kyushu, Japan, on the 17th before filling on the 18th. The largest and most intense storm was typhoon Lorna. First appearing near 16° N., 129° E. on the 20th, Lorna grew rapidly to typhoon intensity. Moving northwestward Lorna's "eye" passed over southern Taiwan on the 24th, reached the China coast on the 25th, and dissipated inland on the 26th.

Tropical storm Marie developed near 23° N., 153° E. on the 29th. This storm moved slowly northward, turned on a westerly course and dissipated early in September, never reaching typhoon strength nor threatening any land areas.

5. THE SUMMER IN REVIEW

Summer of 1961 in the United States was characterized by contrasting regimes of weather associated with an abnormal mid-tropospheric circulation. In figure 6 are shown (A) the average circulation at 700 mb., (B) the departure of average surface temperature from normal, and (C) the total precipitation, for the months of June, July, and August.

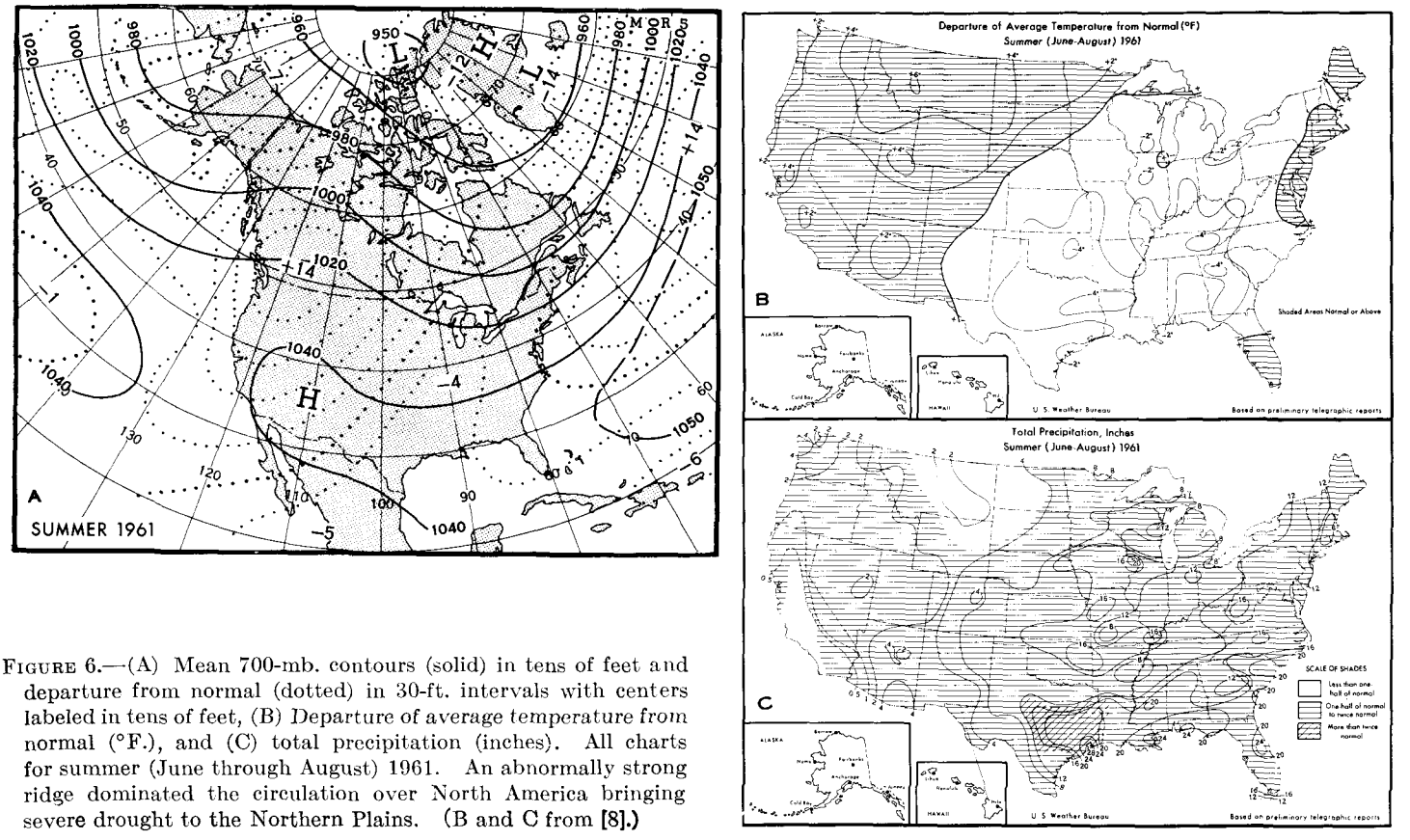

FIGURE 6.—(A) Mean 700-mb. contours (solid) in tens of feet and departure from normal (dotted) in 30-ft. intervals with centers labeled in tens of feet, (B) Departure of average temperature from normal (°F.), and (C) total precipitation (inches). All charts for summer (June through August) 1961. An abnormally strong ridge dominated the circulation over North America bringing severe drought to the Northern Plains. (B and C from [8].)

Unseasonable warmth prevailed throughout most of the western half of the Nation with greatest temperature departures, 4° F. or more, in the Northwest (fig. 6B). This was the warmest summer ever recorded in Walla Walla, Wash. since observations began in 1886. Kalispell, Mont., with a record dating to 1899, also had its warmest summer. Near record warmth was observed elsewhere in the Northwest.

Extreme dryness also prevailed in the area of greatest warmth. At Billings, Mont. this was the driest summer on record, while Devils Lake, N. Dak. experienced its second driest summer.

This hot dry weather regime was accompanied by increasing drought in the Northern Plains, conditions being most severe in northwestern North Dakota and eastern Montana. An index to measure drought severity has recently been developed by Palmer [5]. The index values depend on the temperature and precipitation during each month, the weather during preceding months, the climate of the place being studied, and the duration of the abnormally dry weather. At the end of May 1961 the drought index for northwestern North Dakota was —0.60 (incipient drought stage). By the end of August the index had reached —4.20, comparable to the extreme drought of 1934 when the drought index was —4.17 at the end of August.[2] Crop correspondents of the Department of Agriculture, in their report of September 11, 1961 [6], considered that extreme drought conditions existed in eastern Montana and the western Dakotas.

The tendency for summer drought to follow a warm dry spring in the Great Plains has been shown by Namias [7]. This year appears to be no exception since spring was warm and generally dry in the Northern Plains [8]. Furthermore, these conditions have existed since summer 1960, as is substantiated by the Palmer index which had been at the incipient to mild drought stage since that time.

In marked contrast with the West, most of the eastern half of the Nation enjoyed a cooler than normal summer. Greatest temperature departures (as much as 4° F. in some areas) and near record coolness were observed in the South (fig. 6B). It was the coolest summer ever reported at Baton Rouge, La. in a record dating to 1893, while at Abilene, Tex., this was only the second summer since 1886 that the temperature has failed to reach 100° F.

Precipitation averaged somewhat greater than normal in much of the East and South, with a large area in eastern and central Texas receiving more than two to three times the normal amount (fig. 6C). Most of the latter precipitation fell during June [9] and July [1].

Comparison between the mean 700-mb. circulation pattern for August 1961 (fig. 1) and that for summer of this

[2] A value of —4.00 is considered to be the threshold between severe and extreme drought.

year (fig. 6A) shows them to be remarkably similar in the United States. It follows that persistence of the circulation and weather anomalies was also very high. It is well known that surface temperature anomalies and mid-tropospheric height anomalies are most directly related in summer. Note the close "fit" during the summer of 1961 (figs. 6A, B). The abnormally strong ridge over western North America, with its associated subsidence and northward displaced westerlies tended to inhibit precipitation in the Northwest, with less than half the normal seasonal amounts falling over the Northern Plains (fig. 6C). An examination of the file of 700-mb. mean summer charts in the Extended Forecast Branch discloses that the positive height anomaly center over western North America during this summer was the strongest and most extensive positive anomaly ever observed in this area. Retrogression and deepening of the trough normally found along the east coast in summer was effected primarily by the unusually strong ridge to the west.

REFERENCES

1. R. A. Green, "The Weather and Circulation of July 1961," *Monthly Weather Review*, vol. 89, No. 10, Oct. 1961, pp. 414–418.
2. G. E. Dunn, "Tropical Cyclones," *Compendium of Meteorology*, American Meteorological Society, Boston, 1951, pp. 887–901.
3. H. Riehl, "On the Formation of West Atlantic Hurricanes," Part I of "Studies of Upper-Air Conditions in Low Latitudes," Dept. of Meteorology, University of Chicago, *Miscellaneous Reports*, No. 24, 1948, pp. 1–67.
4. E. M. Ballenzweig, "Relation of Long-Period Circulation Anomalies to Tropical Storm Formation and Motion," *Journal of Meteorology*, vol. 16, No. 2, Apr. 1959, pp. 121–139.
5. W. C. Palmer, "Drought in Northwestern North Dakota," U.S. Weather Bureau, *Weekly Weather and Crop Bulletin, National Summary*, vol. XLVIII, No. 28, July 10, 1961.
6. U.S. Dept. of Agriculture, Statistical Reporting Service, Sept. 11, 1961.
7. J. Namias, "Factors in the Initiation, Perpetuation, and Termination of Drought," *Publication No. 51*, International Association of Scientific Hydrology, Commission of Surface Waters, (IUGG 1960 Meetings in Helsinki), pp. 81–94.
8. U.S. Weather Bureau, *Weekly Weather and Crop Bulletin, National Summary*, vol. XLVIII, Nos. 24, 36, and 37, June 12, September 4, 11, 1961.
9. L. P. Stark, "The Weather and Circulation of June 1961—A Hot, Dry Month in the West," *Monthly Weather Review*, vol. 89, No. 9, Sept. 1961, pp. 368–373.